THE AFWL CHEBS (CONVENTIONAL HIGH EXPLOSIVE BLAST AND SHOCK) TEST SERIES

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ABSTRACT

The objectives of the CHEBS test series are to develop a data base for the blast and shock environments created by conventional high explosive weapons and subsequently to develop appropriate analytical techniques. Both efforts are aimed at producing reliable protective structure design criteria. This paper presents results of this test series. In particular the free-field "close-in" blast and shock environment, bomb-to-bomb variation, and experimental error are examined. Brief results of a statistical analysis are presented.

INTRODUCTION

The design of protective structures to resist the blast effects of conventional general purpose bombs has typically used empirically derived curves that specify parameters of the airblast waveform [1]. These parameters (i.e., peak pressure, time of arrival, positive-phase duration, and positive-phase impulse) have been determined from uncased hemispherical surface bursts of various yields. Cube root scaling of the yield is used to normalize the data so that each parameter can be represented by a single curve rather than a family of yield-dependent curves [2, 3]. Conventional general purpose bombs, however, are not hemispherical and the effects of the case and the shape of the explosive on the airblast waveform, are of concern to the protective design community. Of particular interest are scaled ranges of less than 1 $m/kg^{1/3}$.

The data near the hemispherical bursts are limited and have a lot of scatter. It is therefore not satisfactory to represent the data as a single curve through an estimated mean of the data. It is desirable to represent the data not only by their mean but also by some description of the distribution. The Conventional High Explosives Blast and Shock (CHEBS) test series is being conducted jointly by the Air Force Weapons Laboratory and the New Mexico Engineering Research Institute to produce such a representation.

The test series covers several general purpose bombs. The blast parameters are measured at scaled ranges from ~0.5 to 2.0 $m/kg^{1/3}$. The test design and layout have used a statistically based approach that allows evaluation of the airblast parameters in comparison to experimental error, blast symmetry, bomb-to-bomb differences, and bomb orientation. A complete description of the statistical approach used is included in the presentation entitled "A Statistical Approach to Conventional Weapons Experimentation," in this conference.

TEST BED DESCRIPTION AND LAYOUT

The test bed configuration is shown in Figure 1. The dual gages at the various locations are part of the statistically based approach. Six tests with a specific general purpose bomb have been conducted to date on this test bed. The nose of the bomb has been pointed along each of the 90° axes for four of the tests and nose down for the remaining two tests. The center of gravity of the bomb has been placed at the surface. The tests were conducted using available piezoelectric pressure transducers to measure the airblast pressure history. In the farther scaled ranges (greater than 1.5 $m/kg^{1/3}$) the range of the gage used was probably unreasonably large compared to the peak pressure measured. However, the data do not appear to have significant noise problems.

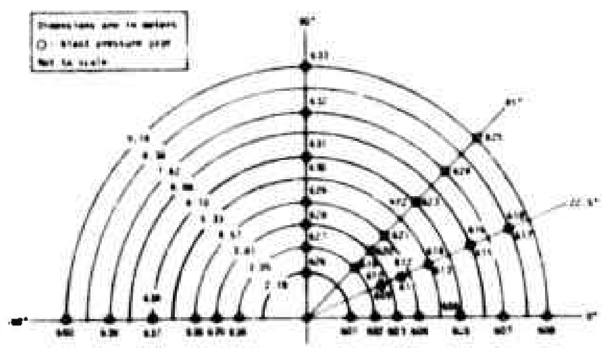

Figure 1. Test bed configuration.

TEST RESULTS AND ANALYSIS

Only peak pressures from the two vertical bombs are presented in this report. Figure 2 shows all of the peak pressure data plotted with range. The data scatter is probably not surprising, but it is desirable to know in quantifiable terms how much of the scatter is random experimental error and how much is related to some system parameter such as bomb-to-bomb variation. Other parameters such as symmetry and bomb orientation variation could and will eventually be considered.

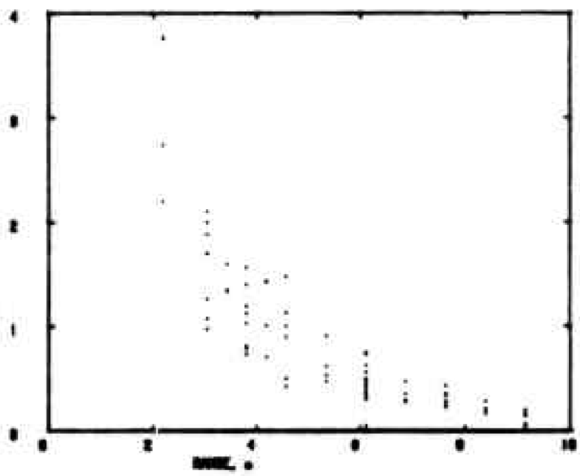

Figure 2. Peak pressure versus range for vertical MK82 general purpose bomb.

Shown in Table 1 is the computation of the pooled variance of corresponding range data from both of the vertical bomb tests. This variance contains both the effects of experimental error and bomb-to-bomb variation. Also shown are the computations for the pooled variance of the pairs of gages from each test. This represents the experimental error for each test. The ratio for the variances for the two tests is compared with the associated F-statistic, and it appears that the experimental error from the two tests comes from the same family of data and are then combined. The experimental error then can be subtracted from the total variance, leaving the bomb-to-bomb variance. The magnitude of bomb-to-bomb standard deviation illustrates that single tests may not be adequate for protective design verification.

A variance that contains not only the bomb-to-bomb variation and the experimental error but also includes symmetrical variation can be obtained by grouping the same data in a different way. All data from both tests at a given range are grouped for this combined variance. Since the bomb-to-bomb variance and the experimental error variance are available, the symmetrical variance can be computed. The total variance is 0.1112.

TABLE I. COMPUTATION OF NORMALIZED VARIANCE FOR VERTICAL BOMBS

TEST	DEGREES OF FREEDOM	NORMALIZED[a] VARIANCE	RATIO	F(95)	POOLED VARIANCE	NOTE
All CHEBS V & VI Data	42				0.0806	1
CHEBS V (constant angle)	5	0.0431	1.66	9.02	0.0367	2
CHEBS V (constant range)	3	0.0260				
CHEBS VI (constant angle)	4	0.0319	1.54	6.39	0.0262	3
CHEBS VI (constant range)	4	0.0269				
CHEBS V	8	0.0367	1.40	3.44	0.0315	4
CHEBS VI	8	0.0262				

[a]Normalized by mean square of the data.

Notes:

1. Contains combined bomb-to-bomb variation and experimental error.
2. Experimental error in CHEBS V.
3. Experimental error in CHEBS VI.
4. Combined experimental error.

Bomb-to-bomb normalized variance = 0.0806 - 0.0315 = 0.0491
Bomb-to-bomb normalized standard deviation = 0.2218

Then

$$\text{symmetrical variance} = 0.1112 - 0.0491 - 0.0315 = 0.0306$$

Thus the total variance is composed of somewhat equal parts of the bomb-to-bomb variance, the symmetrical variance, and the experimental error. A structure could be subjected to peak pressure that could have variance that includes both symmetry and bomb-to-bomb differences. The sum would be a measure of the expected variance of peak pressure. That is

$$0.0306 + 0.0491 = 0.0797$$

which can be interpreted as having a standard deviation of $\sqrt{0.0797}$ or 28.2 percent of the mean peak pressure.

It should be noted here that there may be other effects but they are assumed to be small compared to the effects examined.

CONCLUSION

It is possible to perform conventional weapon testing in such a way as to separate factors that cause scatter in the data so that both the analyst and the designer are informed as to reasonable variations of airblast parameters about their mean values.

REFERENCES

[1] Crawford, Robert E., et al., **Protection from Nonnuclear Weapons**, AFWL-TR-70-127, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico 1971.

[2] Kingery, C. N., **Airblast Parameters Versus Distance for Hemispherical TNT Surface Bursts**, BRL Report Number 1344, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland.

[3] Gürke, G., Scheklinski-Glück, G., Detterer, M., and Mehlin, H. P., **Blast Parameters from Cylindrical Charges Detonated on the Ground**, E6/82, Ernst-Mach I Institute, March 1982.